

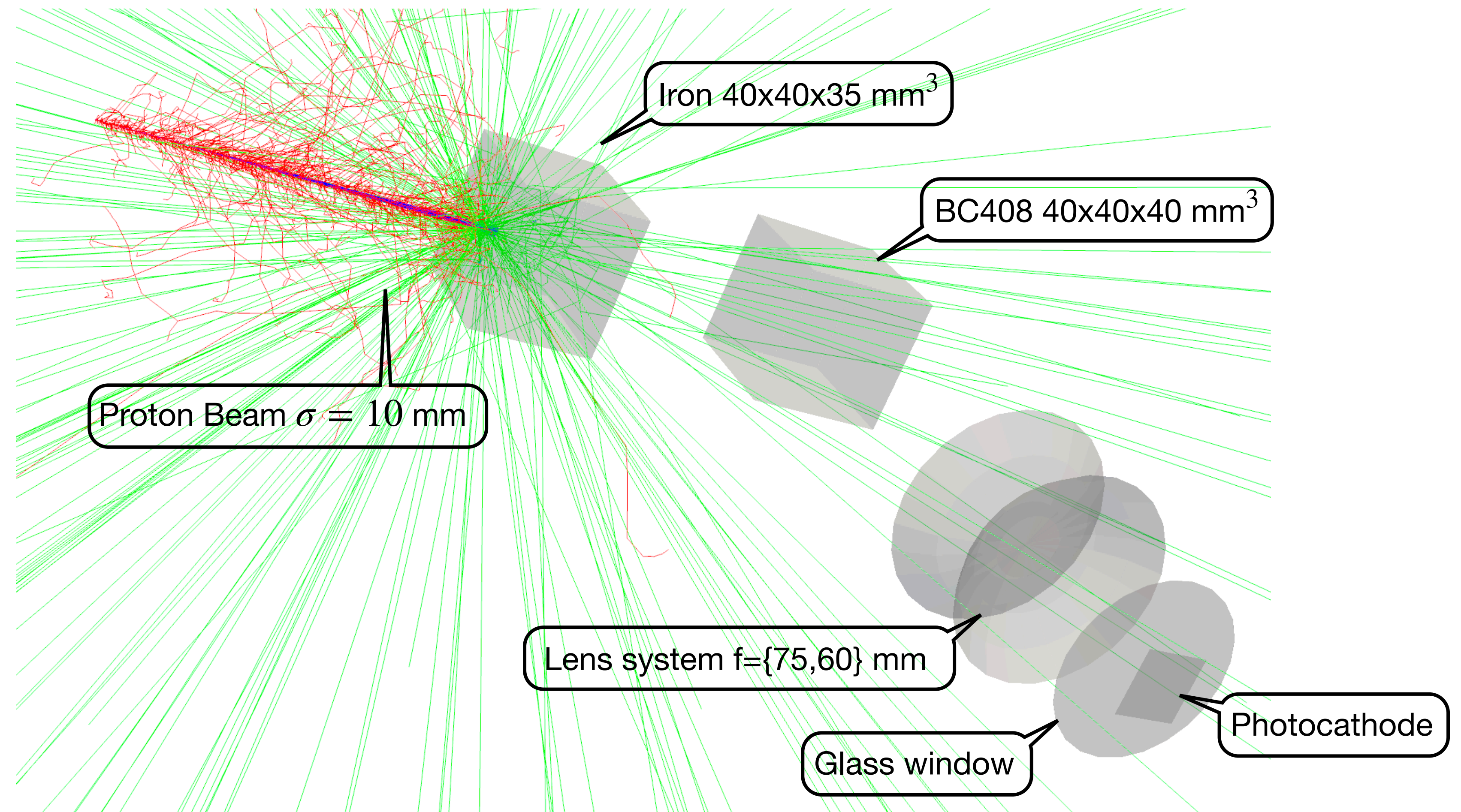
Simulation for the CNAO test beam

Samuele Lanzi - RIPTIDE meeting - 9 Apr 2026

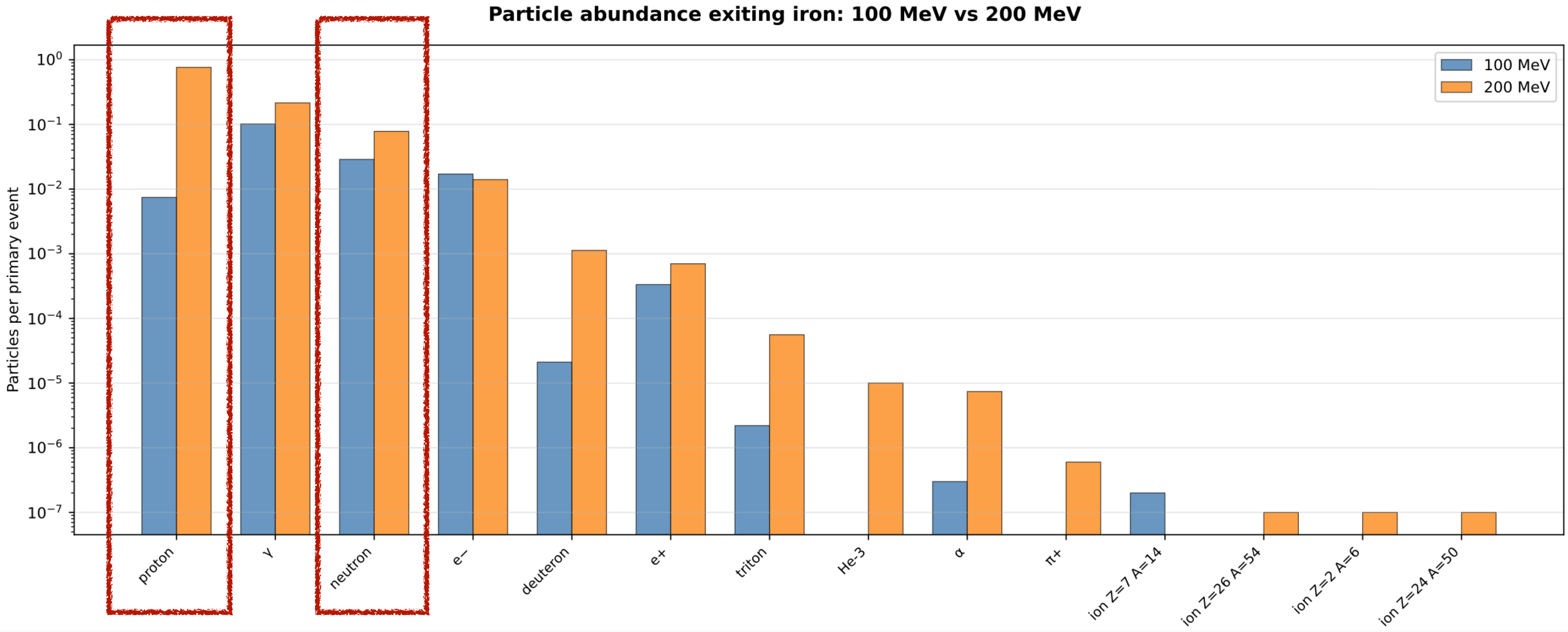
The geometry

2 simulations:

- 10M protons at 100 MeV
- 10M protons at 200 MeV



Particle types per event

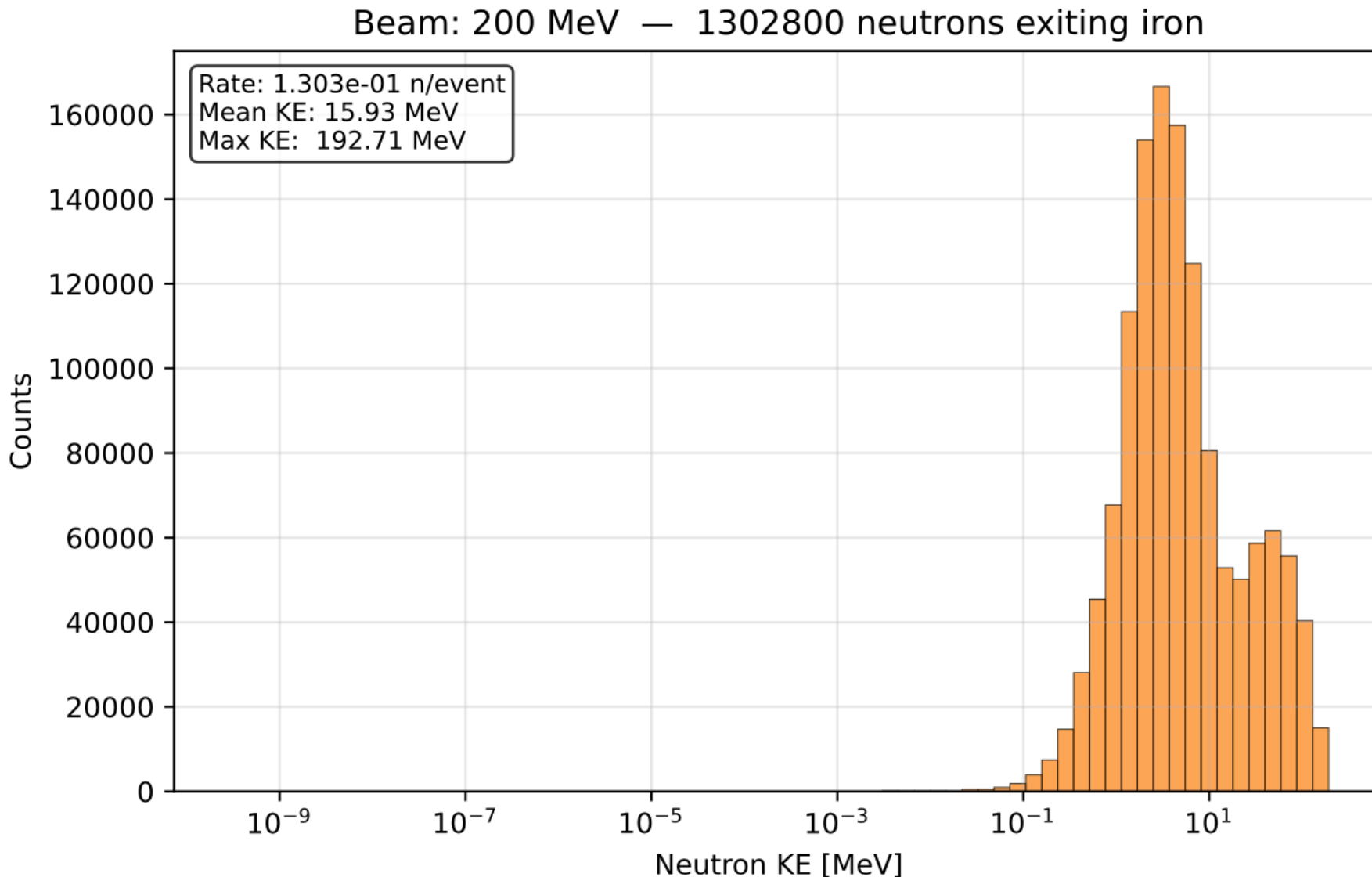
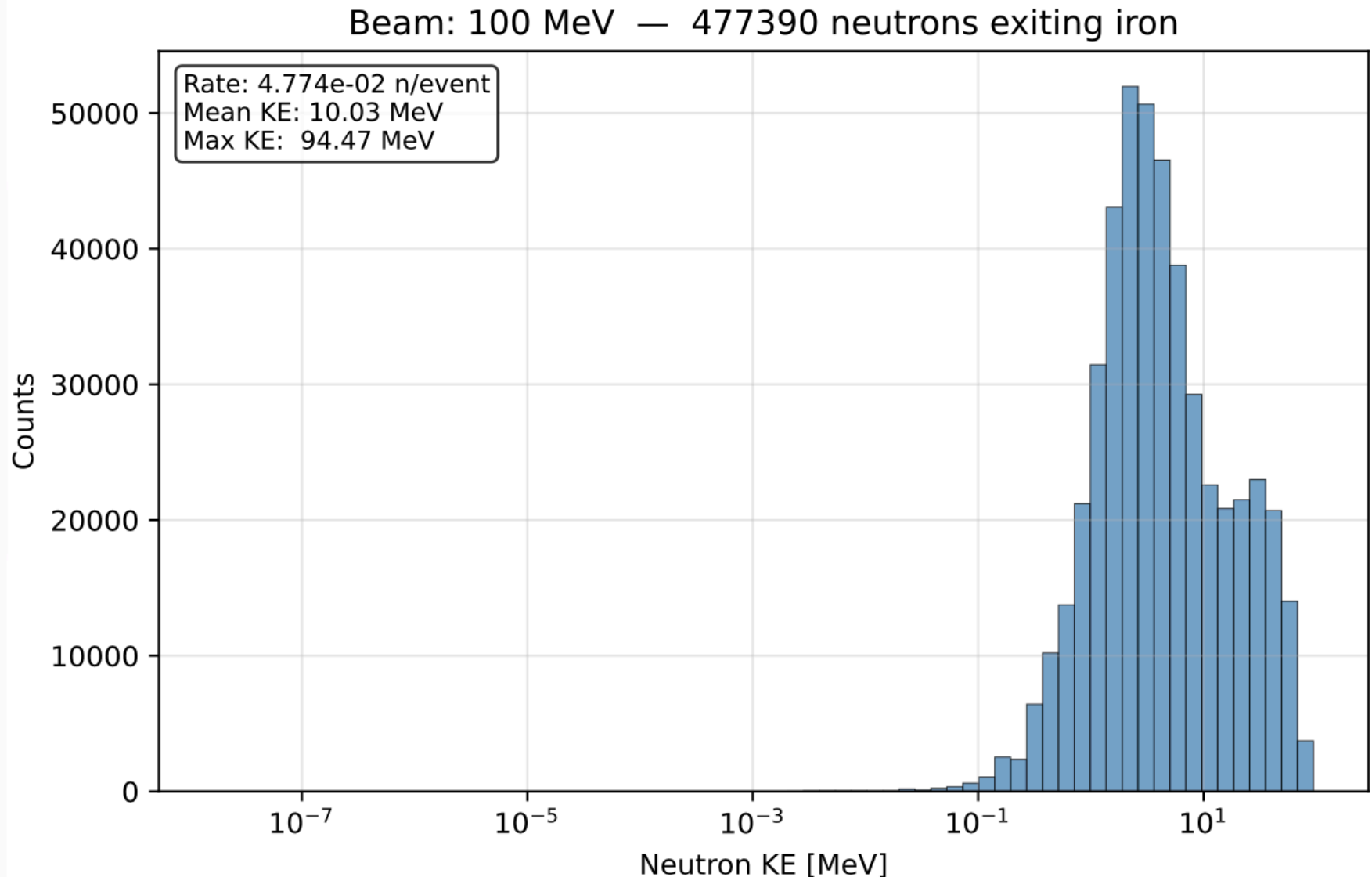


Secondary neutrons

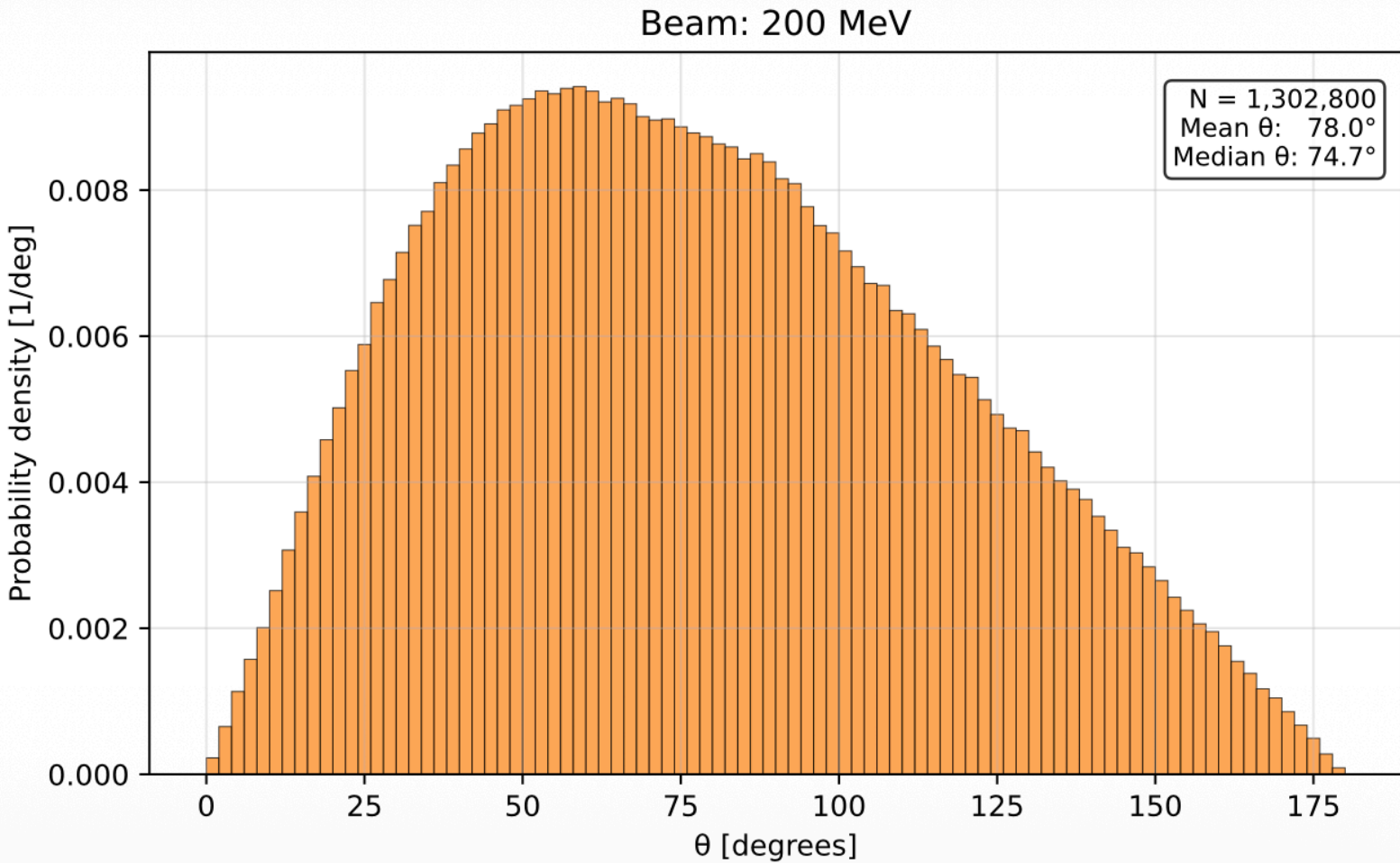
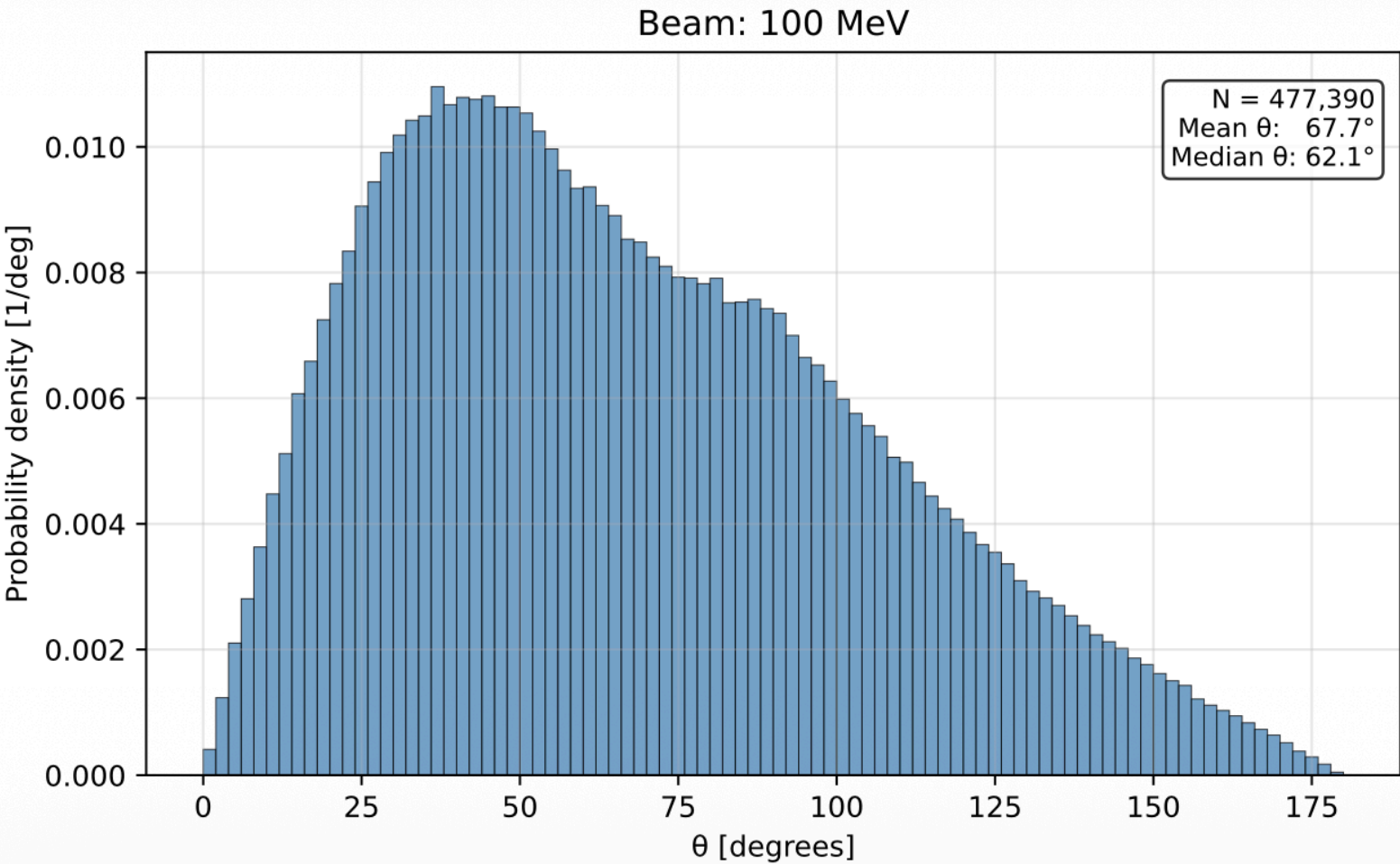
For secondary neutrons:

- Energy spectra
- Exiting direction from Fe

Neutron KE spectrum at iron exit



Angular distribution of neutrons at iron exit
(θ = angle w.r.t. beam axis, $-z$ direction)



Secondary neutrons interacting in the scintillator

Scattering n-p:

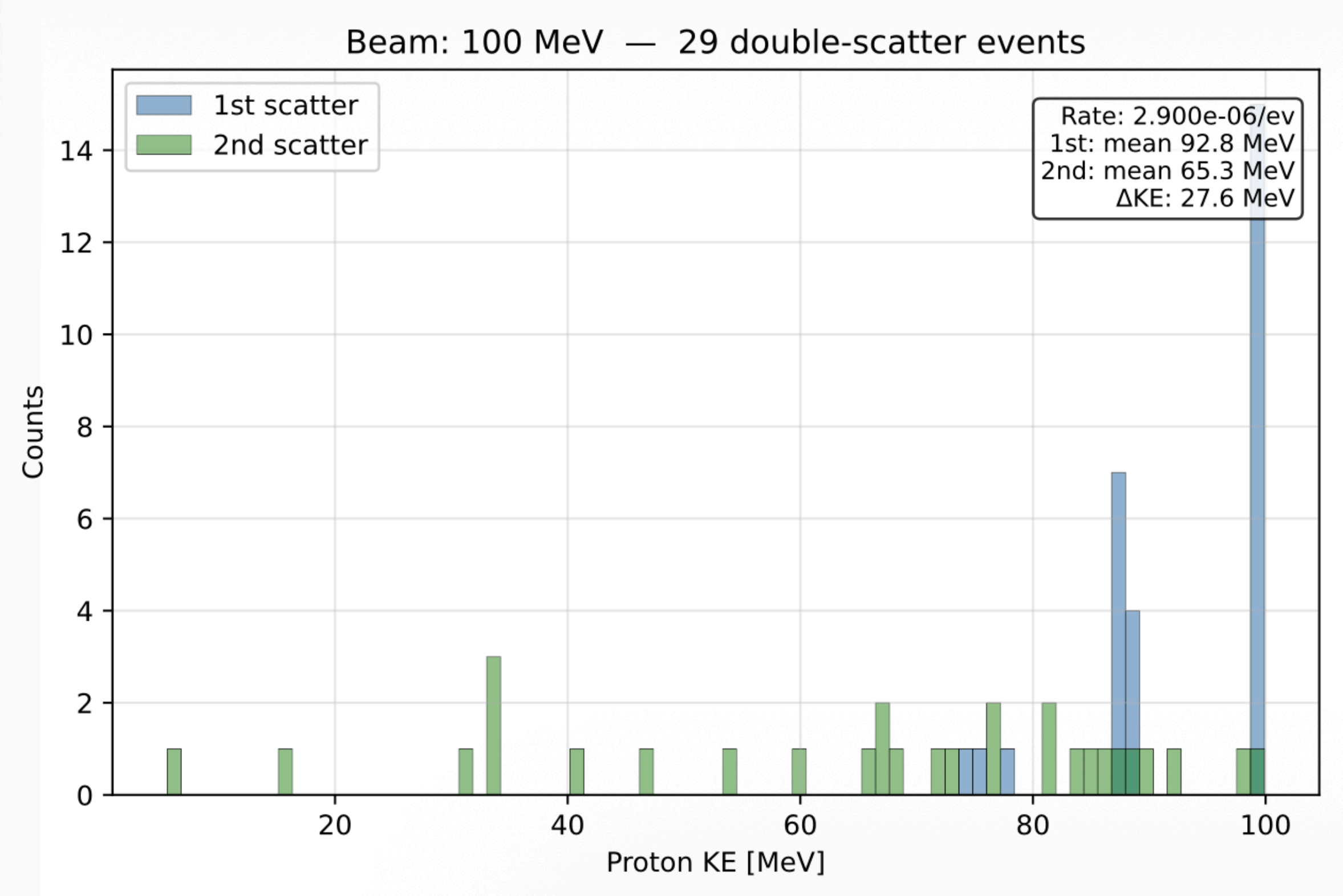
100 MeV

0-scatter: 99.876%
1-scatter: 0.042%
2-scatter: 0.047%
≥3-scatter: 0.035%

200 MeV

0-scatter: 90.994%
1-scatter: 2.087%
2-scatter: 4.281%
≥3-scatter: 2.637%

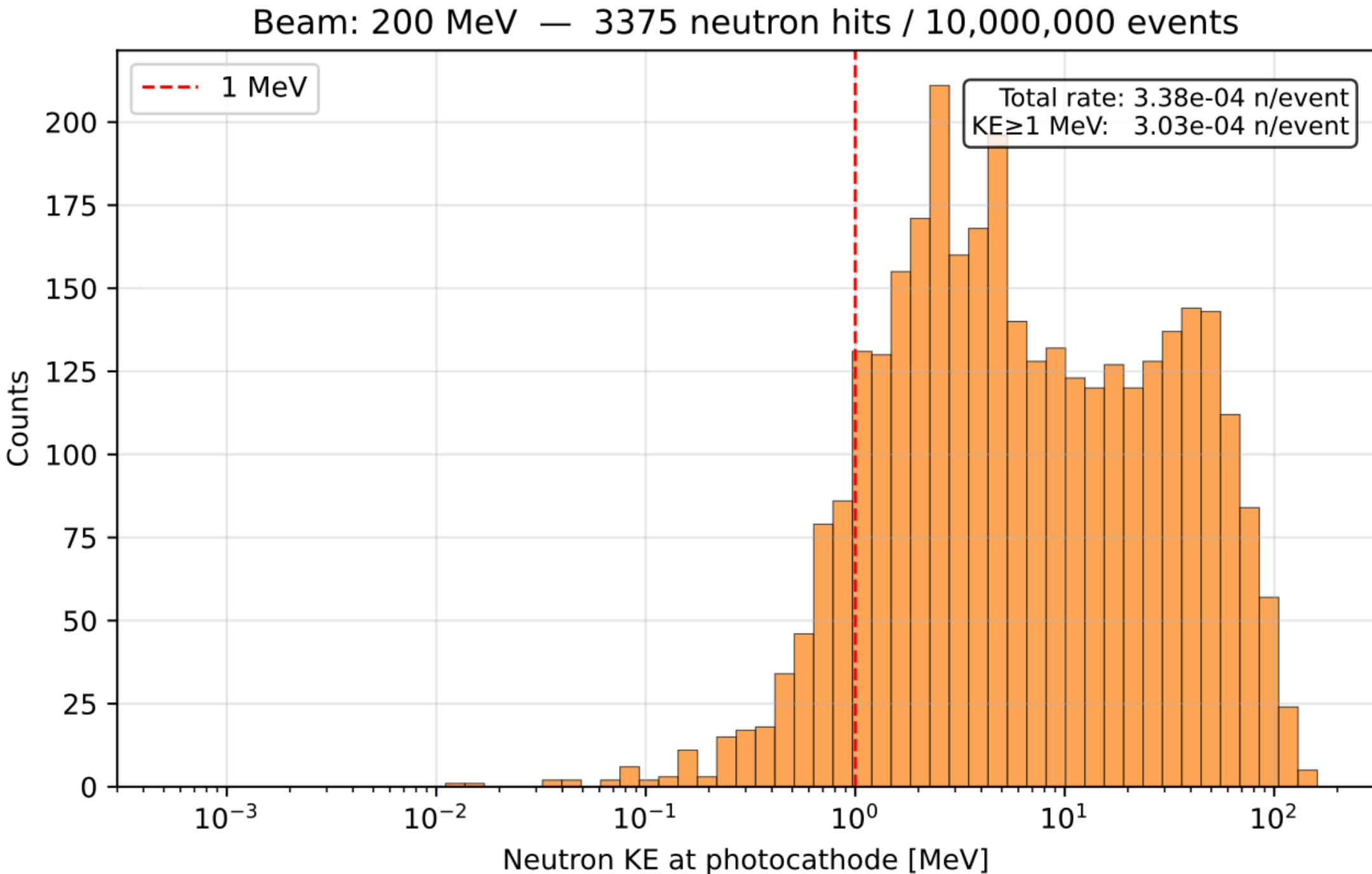
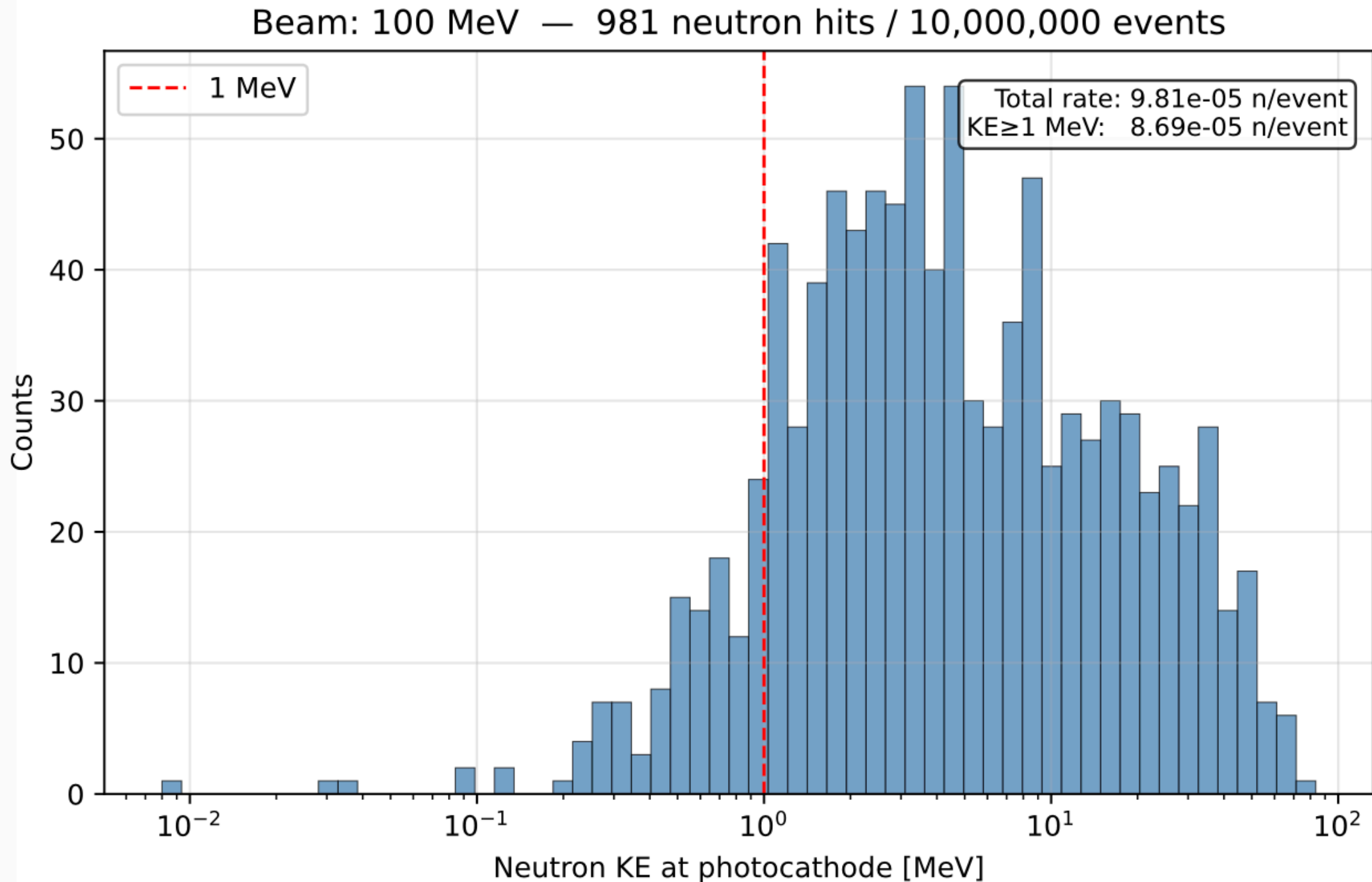
They cannot be distinguished from primary protons



Secondary neutrons interacting with photocathode

⚠ Neutrons interacting with the GaAsP photocathode may drastically reduce its quantum efficiency. Fast neutrons can induce displacement damage in the semiconductor lattice, creating defect centers that degrade its photoemission properties.

Neutrons hitting photocathode (MCP GaAsP damage estimate)



Conclusions

- A Geant4 simulation was developed to study the production of secondary neutrons generated by 100 MeV and 200 MeV protons impinging on a 3.5 cm thick iron slab
- The energy spectra and angular distributions of the secondary neutrons were presented and discussed
- For 100 MeV primary protons, the energy distributions of protons arising from double scattering events were analyzed
- For 200 MeV protons, a greater iron thickness is required to stop the majority of the primary beam
- A potential risk to be addressed is the interaction of secondary neutrons with the GaAsP photocathode, which may degrade its quantum efficiency through displacement damage
- As a future development, the propagated images on the sensor will be analyzed to investigate whether a reconstruction of the incident direction and energy of the neutron can be achieved

Neutron KE vs emission angle at iron exit

